Air-Sea Interaction Spar Buoy Systems

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LONG-TERM GOALS

The long term goal is to enhance our equipment and instrumentation to measure directly air-sea interaction fluxes and high-resolution directional wave spectra and improve our understanding of the atmosphere-ocean dynamics in typhoon conditions.

The principal task of this project is to acquire two new modular spar components which form the basis for our air-sea interaction spar (ASIS) buoy and purchase suitable instrumentation for measuring wave spectra, turbulence and marine fluxes for the Typhoon DRI experiment.

OBJECTIVES

The quest to obtain better and direct measurements of the air-sea fluxes in storm conditions led to the design of a stable floating platform which allowed measurements of turbulence in the atmospheric and oceanic boundary layers with minimal corrections. The air-sea interaction spar (ASIS) buoy fulfills these requirements with minimal flow distortions and a modular design.

Specific objectives are:

1) To improve the structural design of ASIS to withstand extreme air-sea interaction conditions as those in hurricanes and typhoons.

2) To use better measurement strategies and instrumentation that provide high-resolution turbulence and flux measurements near the air-sea interface.

3) To improve the data acquisition system to allow storage or longer data records and extend autonomous operations to six months.

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4) To use more rugged wave staff wires in storm-forced sea states.

APPROACH

We are building on the previous success of the ASIS buoy and better state-of-the-art instrumentation and new sensing technology to obtain data on air-sea interaction. With this new instrumentation we could build on our previous success and begin to explore research topics previously not readily performed in open ocean conditions. Such topics are:

Upper Ocean Dynamics:
The accurate measurement of the wavenumber-directional spectrum, and its spatial and temporal variation, is key to determining the overall energy (or wave action) budget. Typically, however, most in situ field measurements of waves yield the frequency-directional spectrum. This is significant in that Doppler shifting of the wave components by longer waves and currents results in the apparent (measured) frequency being different from the real or intrinsic frequency. Hence, the wavenumber-directional spectrum cannot be fully determined from the measurements. In particular, the high frequency waves, including those significant to Bragg scattering, will be strongly affected.

The occurrence of wave breaking has important consequences for mixing in the upper layers (TKE enhancement) and also is believed to affect wave generation. Simultaneous measurements of wave (wavenumber) directional properties and local slope and pressure above the waves are key to understanding the wave generation problem on the ocean.

Ocean Turbulence:
Hot wire/film anemometry has a special place in fluid dynamics research, but they cannot be easily deployed in open ocean conditions. On the other hand Acoustic Doppler Velocimeters (ADVs) can measure at high rates the turbulence in the upper ocean layers. ASIS provides a unique platform to make such measurements in the upper 1 to 10 meters below the wavy ocean surface. ASIS is designed to behave like a spar for short gravity waves (< 8 seconds) and ride like a wave follower with the longer swell thus providing a relatively constant distance to the air-water interface.

Air-Sea Interaction:
The correct parameterization of fluxes at the air-sea interface involves knowledge of the radiative fluxes and turbulent flux-gradient relationships under a wide range of conditions of stability, wave development and non-stationarity and inhomogeneity. The ASIS buoy makes this a suitable platform from which to make surface flux, profile, directional wave and radiation measurements and a reliable system of making and recording these measurements. The measurement of fluxes at the air-sea interface and the parameterization of gradients in the surface layer are key aspects of understanding the general problem of the coupling of atmosphere and oceans. Effects of sea state and density gradients in the surface layer (stratification) have been shown to play a critical role in parameterizing air-sea interactions.

There is also growing evidence that the presence of waves on the ocean surface influence the calculation of wind stress in two ways:

i. Experimental results have shown that the aerodynamic drag coefficient depends on sea state, because the roughness of the sea surface is coupled to waves. Such a relationship might be intuitive from studies of fluid flow over solid walls, but in practice a description of the sea surface roughness is complicated by the fact that waves are mobile and constantly evolving in space and time.

ii. Recent observations suggest that the direction of the surface wind stress is not co-aligned with the direction of the wind when swell and/or large wind waves are present. Swell waves propagate in directions independent of the wind direction and it is believed that swell-induced orbital velocity modulations of roughness steer the direction of the stress towards the wave direction.

It is obvious from the above statements that surface waves play a crucial role in air-sea interaction, particularly for specifying the correct wind and wind stress vector. In turn, winds and stresses drive ocean models and are used in mixed-layer studies to estimate the wave-induced momentum flux into the upper layer and to determine the depth of the mixed layer.

The “new” ASIS buoy (Figure 1) serves as an excellent platform for validating radar measurements of wind and wind stress, directional wave spectra and wave height from airborne and space-based sensors such as scatterometers, altimeters and synthetic aperture radars and for measuring radiation properties at the sea surface which can be correlated to relevant air-sea interaction parameters. Figure 1 shows a typically equipped ASIS ready for deployment.

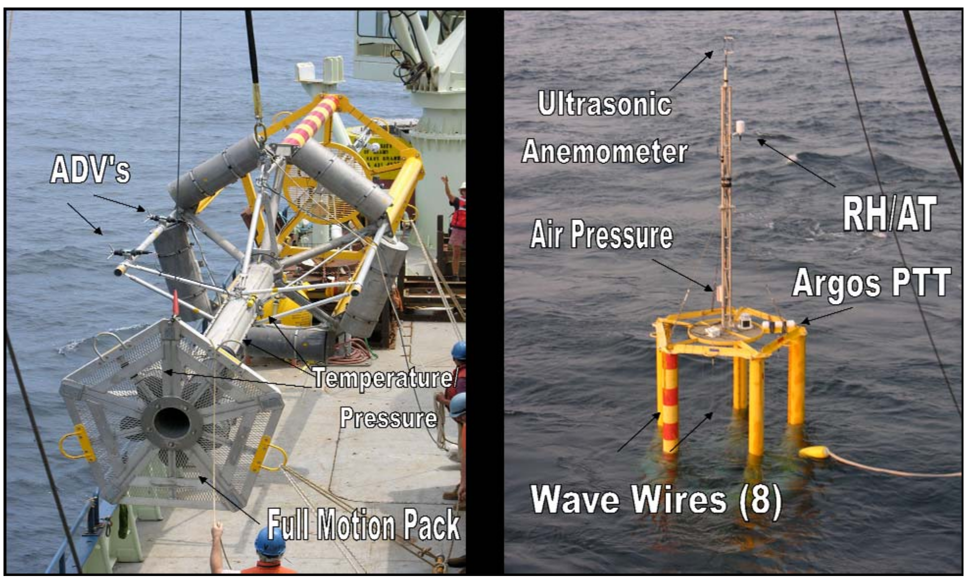

Figure 1: The ASIS buoy during a recent deployment and deployed at sea.

WORK COMPLETED

1) Two new ASIS buoys have been manufactured.
2) Two surface tether buoys have been acquired.
3) New instrumentation such as deep ocean acoustic releases, linear accelerometer triplets and rate gyros has been purchased.

4) Two new data acquisition system with new computational and recording technologies have been build to store high resolution data at a rate of 20 Hz for six months and measure at high resolution the six-degrees of motion of the ASIS buoy.

RESULTS

Two new ASIS buoys were manufactured and are now prepared for the experimental phase of the Typhoon DRI in 2010. For the remainder of the year, new instrumentation acquired will be tested and calibrated in preparation for the 2010 field experiment.

IMPACT/APPLICATIONS

None yet.

TRANSITIONS

None. Project just started.

RELATED PROJECTS

None. Project just started.